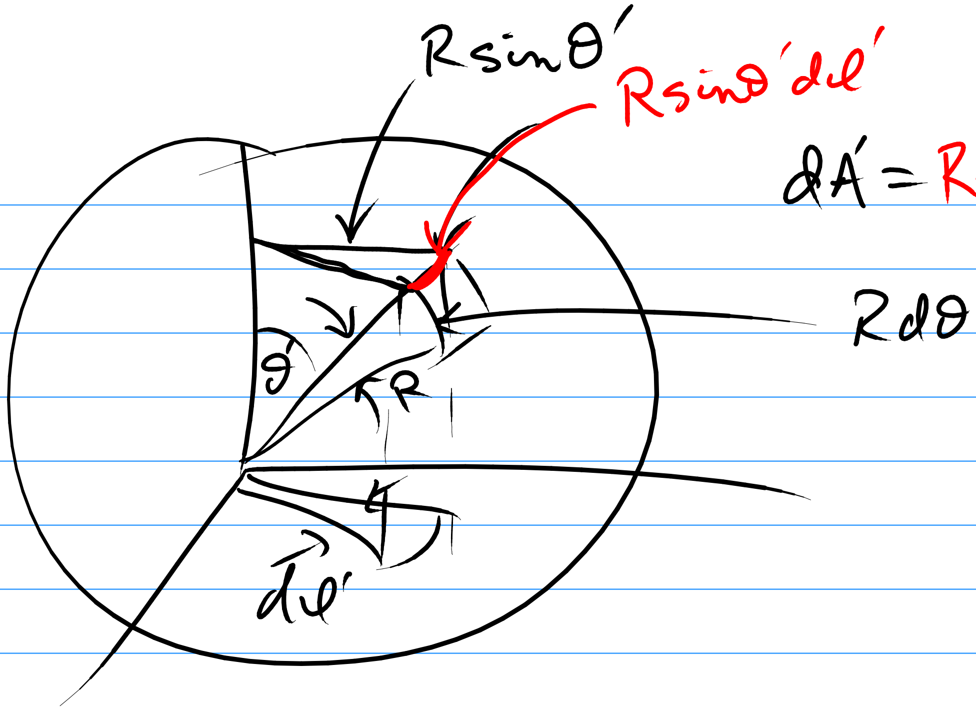


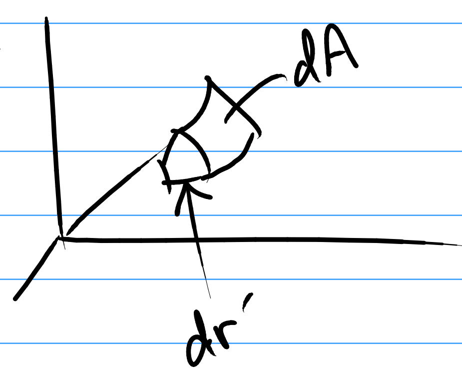
$$dA' = R\sin\theta'\,d\phi'\,R\,d\theta'$$

calculate area of spheres, cylinders using calculus

$$\text{Surface area} = \int dA' = \int_0^{2\pi}\int_0^{\pi} R^2 \sin\theta'\,d\theta'\,d\phi' = 4\pi R^2$$

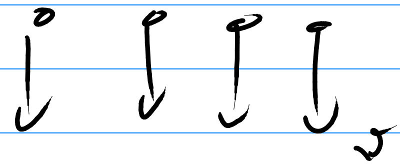
volume element $= d\tau$

$$d\tau = dr'\,dA'$$



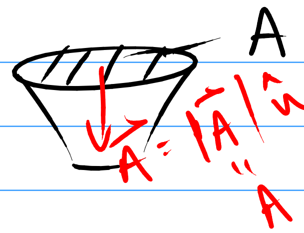
$$= r'^2 \sin\theta'\,d\theta'\,d\phi'\,dr'$$

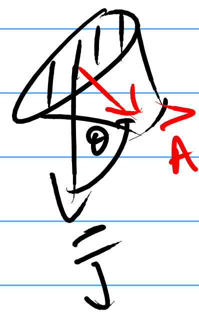
$$\text{Volume} = \int d\tau = \int_0^{\pi}\int_0^{2\pi}\int_0^{R} r'^2 \sin\theta'\,d\theta'\,d\phi'\,dr' = \frac{4}{3}\pi R^3$$



$\vec{J}\left(\frac{\#\text{ particles}}{s \ \text{Area}}\right)$

current density





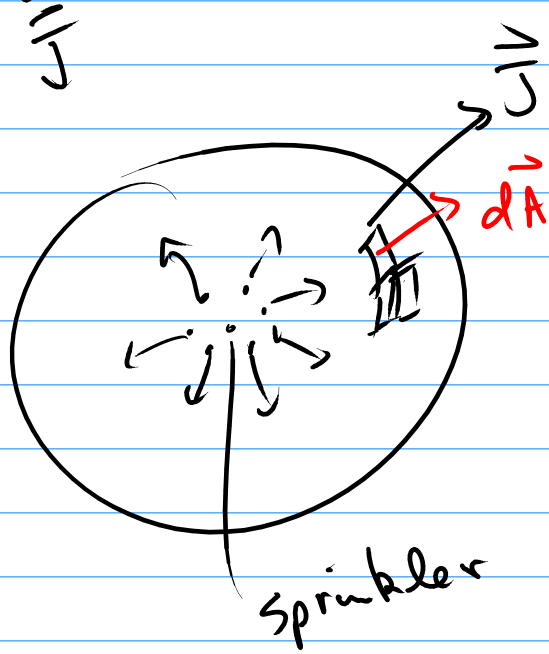
$\vec{J}\cdot\vec{A} = JA\cos\theta = \Phi$

flux

$d\Phi = \vec{J}\cdot d\vec{A}$

$= J\,dA\cos\phi$

$\Phi_{\text{spherical surface}} = \int d\Phi = \int \vec{J}\cdot d\vec{A}$



$J \propto \frac{1}{r^2}$ total area of sphere $\propto r^2$

$\oint \vec{J}\cdot da = \dot{S}$

closed surface

$\frac{\text{particles}}{s}$

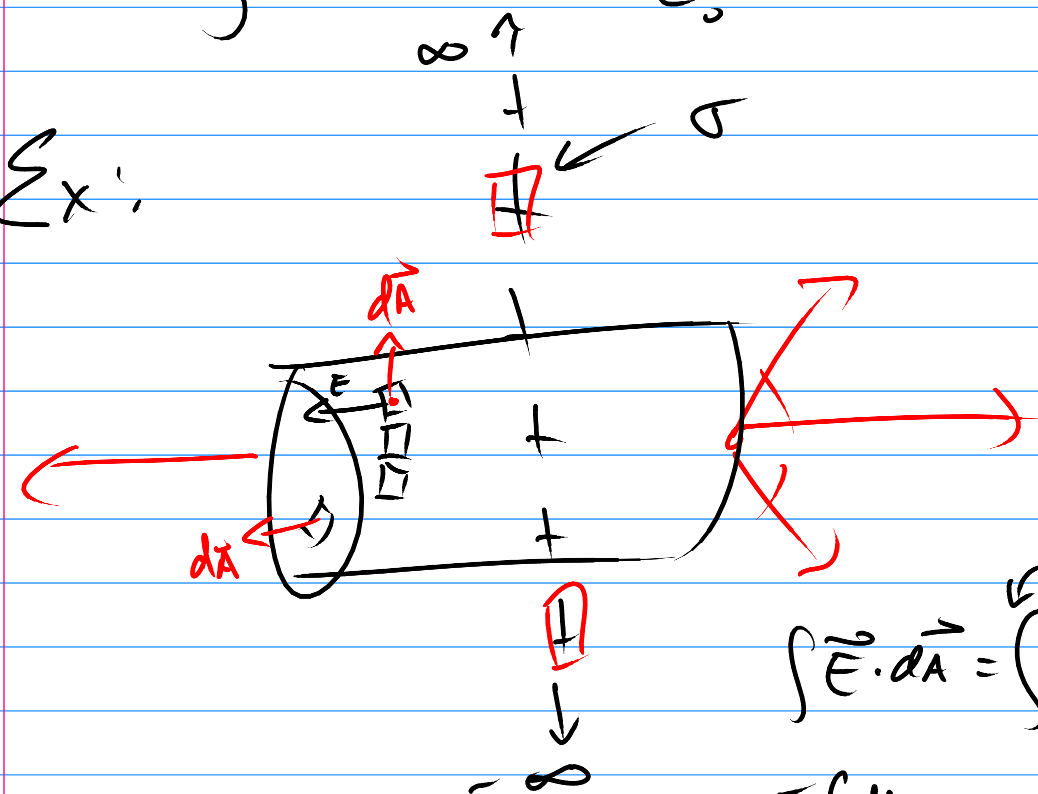
Electrostatics $\vec{J} \longleftrightarrow \vec{E}$

$S \longleftrightarrow Q$

particles Electric field

$$\oint \vec{E}\cdot d\vec{a} = \frac{Q}{\epsilon_0}$$ Gauss's Law

Ex:



$$\int \vec{E}\cdot d\vec{A} = \int E\,dA\cos\phi$$

$$= E\int dA = E\pi R^2$$

$$\oint \vec{E}\cdot d\vec{A} = \int_{cap} + \int_{cap} + \cancel{\int_{\underset{0}{body}}} = 2E\pi \cancel{R^2} = \frac{\sigma\pi\cancel{R^2}}{\epsilon_0}$$

$$E = \frac{\sigma}{2\epsilon_0}$$